THE GOLDEN RATIO

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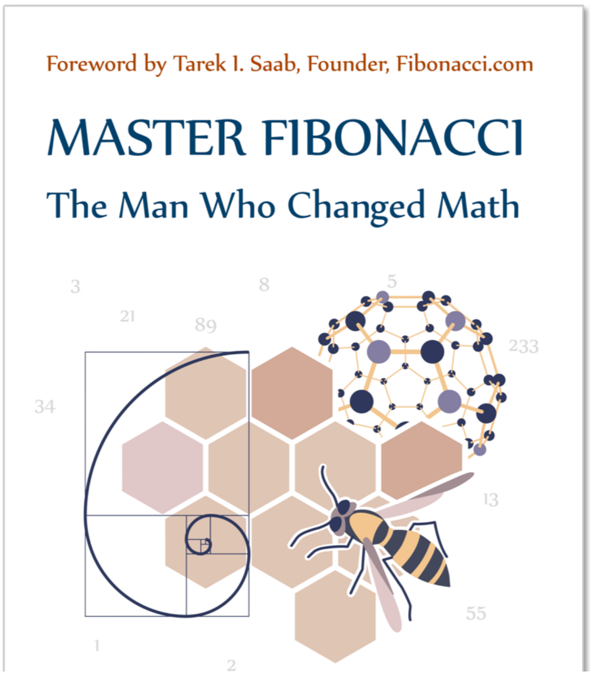
THE GOLDEN RATIO

(Previous Section: *Phi*)



Euclid's ancient ratio had been described by many names over the centuries but was first termed "the Golden Ratio" in the nineteenth century. It is not evident that Fibonacci made any connection between this ratio and the

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(Euclid). It was not until the late seventeenth century that the relationship between Fibonacci numbers and the Golden Ratio was proven (and even then, not fully) by the Scottish mathematician Robert Simson (1687-1768) (Livio 101).

The Greek letter tau (Ττ) represented the Golden Ratio in mathematics for hundreds of years but recently (early in the 20th century) the ratio was given the symbol phi (Φ) by American mathematician Mark Barr, who chose the first Greek letter in the name of the great sculptor Phidias (c. 490-430 BCE) because he was believed to have used the Golden Ratio in his sculptures and in the design of the Parthenon (Donnegan; Livio 5). [The verity of these and other claims (such as that the Golden Ratio is found in paintings, Egypt's pyramids, and measurements of proportions in the human body) is addressed in "Fibonacci in Art and Music."] German mathematician Martin Ohm (brother of physicist Georg Simon Ohm, after whom Ohm's Law is named) first used the term "Golden Section" to describe this ratio in the second edition of his book, *Die Reine Elementar-Mathematik (The Pure Elementary Mathematics)* (1835). He wrote: "One also customarily calls this division of an arbitrary line in two such parts the 'Golden Section.'" He did not invent the term, however, for he said, "customarily calls," indicating that the term was a commonly accepted one which he himself used (Livio 6).

What is the Golden Ratio? (2 of 5)

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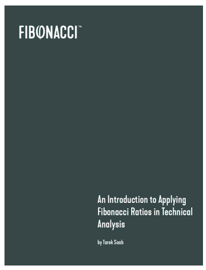

An

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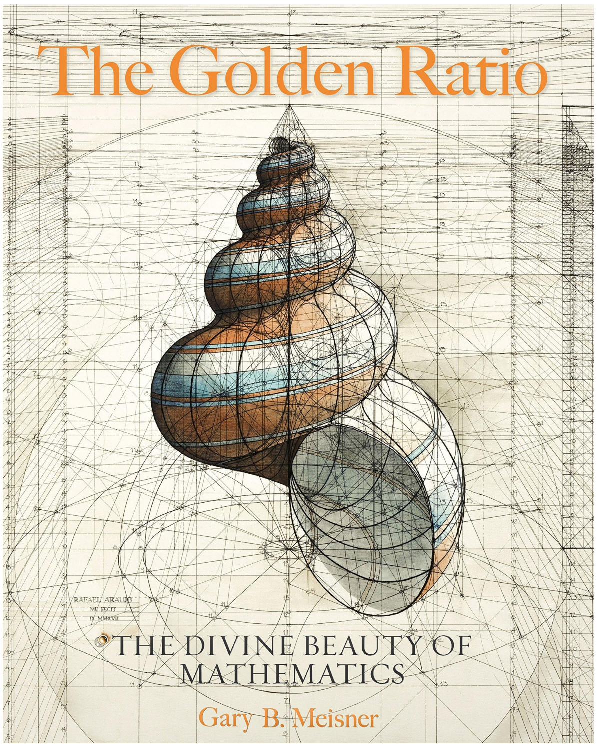
The Golden Section number for phi (φ) is 0.61803 39887…, which correlates to the ratio calculated when one divides a number in the Fibonacci series by its successive number, e.g. 34/55, and is also the number obtained when dividing the extreme portion of a line to the whole. This number is the inverse of 1.61803 39887… or Phi (Φ), which is the ratio calculated when one divides a number in the Fibonacci series by the number preceding it, as when one divides 55/34, and when the whole line is divided by the largest section. The Golden Ratio formula is: F(n) = (x^n – (1-x)^n)/(x – (1-x)) where x = (1+sqrt 5)/2 ~ 1.618.



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Another way to write the equation is:

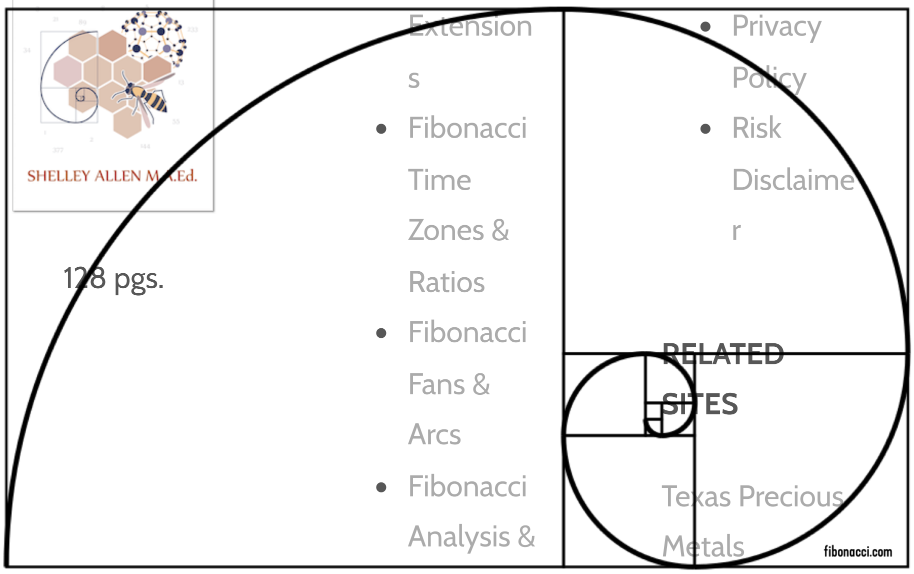
$$\varphi = \frac{1+\sqrt{5}}{2} = 1.6180339887\ldots$$

Therefore, phi = 0.618 and 1/Phi.

The powers of phi are the negative powers of Phi. One of the reasons why the Fibonacci sequence has fascinated people over the centuries is because of this tendency for the ratios of the numbers in the series to fall upon either phi or Phi [after F(8)].

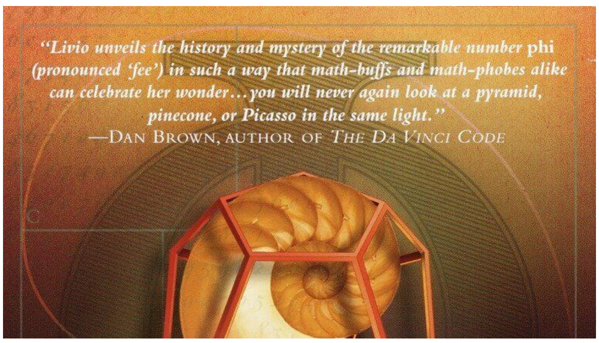
Fibonacci Spiral

The limits of the squares of successive Fibonacci numbers create a spiral known as the Fibonacci spiral; it follows turns by a constant angle that is very close to the Golden Ratio. As a result, it is often called the golden spiral (Levy 121).



The Golden Spiral

A true Golden spiral is formed by a series of identically proportioned Golden Rectangles, so it is not exactly the same as the Fibonacci spiral, but it is very similar. As the Fibonacci spiral increases in size, it approaches the angle of a Golden Spiral because the ratio of each number in the Fibonacci series to the one before it converges on **Phi, 1.618**, as the series progresses (Meisner, "Spirals").



Many natural phenomenon (e.g. rotations of hurricanes and the spiral arms of galaxies) and objects

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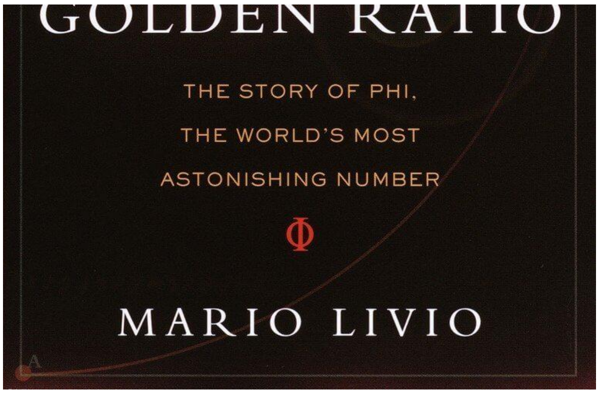

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example, the shell of the chambered nautilus (Nautilus pompilius) and the arrangement of seeds in a sunflower head are obviously arranged in a spiral, as are the cone scales of pinecones (Knott, “Brief;” Livio 8). Fibonacci spirals, Golden Spirals, and Golden Ratio-based spirals often appear in living organisms. However, not every spiral in nature is related to Fibonacci numbers or Phi; some of these spirals are equiangular spirals rather than Fibonacci or Golden Spirals. An Equiangular spiral has unique mathematical properties in which the size of the spiral increases, but the object retains its curve shape with each successive rotation. Fibonacci numbers appear most commonly in nature in the numbers and arrangements of leaves around the stems of plants, and in the positioning of leaves, sections, and seeds of flowers and other plants (Meisner, “Spirals”).

Many observers find the patterns of Fibonacci spirals and Golden Spirals to be aesthetically pleasing, more so than other patterns. Therefore, some historians and students of math assign exceptional value to those objects and activities in nature which seem to follow Fibonacci patterns.

OTHER MATH APPLICATIONS

Fibonacci and Fractal Structures: Possibilities

Computer design specialists use algorithms to generate fractals which can produce complex visual patterns for computer-generated imagery (CGI) applications. Researchers in the Plasma Physics Research Center, Science and Research Branch, at Islamic Azad University, (Tehran, Iran) have created three variations of special fractal structures, Fibonacci fractal photonic crystals, which "could be used to develop resonant microcavities with high Q factor that can be applicable in [the] design and construction of ultrasensitive optical sensors." Possible commercial use of these structures include the production of complex visual patterns for computer-generated imagery (CGI) applications in fractal Personal Computers. Gaming enthusiasts will certainly welcome such advances in PC construction (Tayakoli and Jalili).

Fibonacci and the Physical Sciences

Kepler and others have observed Phi and Fibonacci sequence relationships between objects in the solar system and today there are websites whose curators offer propositions of their own about whether or why there are Phi relationships between the principles governing interplanetary and interstellar interactions, gravitational fields, electromagnetic fields, and many other celestial movements and forces. For example, some conclude that the Phi-related "feedback" in perturbations between the planets and the sun has the purpose of arranging the "planets into an order which minimizes work done, enhances

Learned and William Ditto from the University of Hawaii, Mānoa, realized that frequencies driving the pulsations of a bluish-white star 16,000 light-years away (KIC 5520878) were in the pattern of the irrational "Golden Number" (Wolchover). Atomic physicist Dr. Rajalakshmi Heyrovska has discovered through extensive research that a Phi relationship exists between the anionic to cationic radii of electrons and protons of atoms, and many other scientists have seen Phi relationships in geology, chemical structures and quasicrystalline patterns ("Phi;" TallBloke). The fact that such astronomically diverse systems as atoms, plants, hurricanes, and planets all share a relationship to Phi invites some to believe that there exists a special mathematical order of the universe.

NEXT SECTION: GEOMETRIC CONSTRUCTIONS INVOLVING PHI